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National Institute Economic Review 2004 187: 58
DOI: 10.1177/00279501041871006

PRODUCTIVITY IMPACTS AND SPILLOVERS FROM FOREIGN OWNERSHIP IN THE UNITED KINGDOM

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In this paper, we measure the indirect impact of FDI on the total factor productivity of domestic plants in a number of UK manufacturing industries, 1974–95, using a standard production-function-based approach. We use data from the UK ARD and information derived from UK input-output tables. Our results indicate that the competition and 'absorption capacity' effect at times outweighs potential benefits, leading to negative spillovers. We also find that inter-industry spillovers are generally more prevalent than intra-industry spillovers. We conclude that the nature of spillovers is such that measurement techniques traditionally adopted fail to explain adequately their complex and diverse nature.

1. Introduction

The theoretical benefits from foreign direct investment (FDI) are well documented (Dunning, 2000; Caves, 1996). Evidence of direct benefits is less clear cut (Harris and Robinson 2003), though it is argued that, aside from these direct benefits, less tangible indirect benefits are likely to 'spill over' to the industry and economy at large, from an upskilling of the labour force (Driffield and Taylor, 2001), the introduction of new and superior technology and techniques (Barrell and Pain, 1997 and 1999) and the introduction of new and improved products (Mansfield and Romeo, 1980).

It has been widely acknowledged that such spillovers could be substantial, though measuring them is, by their indirect nature, likely to be difficult. Estimates have tended to be at the aggregate level or through a case study approach (see Blomstrom, Globerman and Kokko, 2000, for a review). Both methods have their limitations. Moreover, much of the industry level empirical research carried out fails to consider inter-industry spillovers which, it has been argued, may be greater than intra-industry spillovers (Kugler, 2001).

In this paper, plant level data for twenty industries in the manufacturing sector are used. These data, based on the returns obtained by the ONS from the annual census of production, cover the period 1974–95. The model estimates total factor productivity (TFP) at the plant level, taking account of both intra-industry spillovers and (using information from UK manufacturing input-output tables 1990) forward and backward inter-industry spillovers. This paper also includes an agglomeration measure to see if there are any locational spillovers from FDI. The approach adopted generally follows that of Aitken and Harrison (1999), but goes further in that we allow for inter-industry effects as well. In addition, we use a GMM modelling technique to account for problems of endogeneity when modelling TFP.

The results from the twenty industries selected indicate much heterogeneity in the impact of foreign ownership. Most importantly, this study highlights the fact that locational and intra-industry spillovers are less common than is assumed in much of the literature and also that spillovers may be negative as well as positive. Such findings may potentially have significance for policy implementation and the encouragement of inward investment purely on the grounds of potential regional and industry spillovers. The paper is organised as follows: section 2 reviews the theoretical literature on FDI in relation particularly to spillovers, while section 3 considers recent empirical findings from spillover studies. The fourth section provides an overview of the data and the methodological approach adopted, and section 5 presents our results and provides some interpretation. The final section considers the implications of our findings and suggestions as to where future research in this area might be directed.

2. The 'theory' of spillovers from FDI

Accepted theory states that multinational corporations (MNCs) possess some firm-specific asset that makes

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entry into a foreign market, with all its entry costs and associated disadvantages, still profitable, indeed more profitable than other forms of overseas supply such as franchising or licensing (Hymer 1976). These advantages may be in the form of superior technology and better processes (both product and organisational) or be based on a branding advantage.[1] From the perspective of a host government, FDI is generally viewed positively and actively encouraged, with benefits arriving from three basic sources. Firstly, there is the injection of 'healthy' competition, raising the productivity of an industry; this is the 'batting average' effect (Barrell and Pain, 1997) stemming from the fact that MNCs are likely to be operating at the technological frontier.[2] Secondly, there are the direct effects of increasing the demand for labour and from the capacity increasing injection of capital – both of which have wider regional and national benefits. Finally, there are the potential benefits that spill over from MNCs in a more indirect fashion. Firm-specific advantages are not fully internalised. Thus there are uncompensated benefits that leak from the MNC into local industry, to its upstream and downstream customers and suppliers and to the region in which it is based. Such 'spillovers' (both in terms of transfers of technology, especially to suppliers, and in terms of upgrading skills in the local labour market as workers transfer between firms) clearly can benefit domestic plants, especially in industries that have high levels of (spatial) concentration (i.e., through a clustering effect – see Cantwell *et al*., 2001).

MacDougall (1960) was the first to include spillovers when trying to measure the full welfare effects of FDI (see the discussion in Blomstrom and Kokko, 1998). Since then, studies have been undertaken covering many countries at the aggregate level, at the industry level and through case studies at the company level. The majority of the literature on spillovers from FDI is empirical, though some attempts have been made to provide a more rigorous theoretical definition and framework (c.f. Kugler, 2001). Fundamentally though, spillovers seem to suffer from a definition problem. The term 'spillovers' has been used in much of the literature as a cover-all term, to pick up the *perceived* residual benefits from foreign direct investment (FDI), which accrue to indigenous firms and for which foreign firms are *uncompensated,* raising the overall level of productivity.

Here we attempt to define the three levels at which spillovers may impact on indigenous firms, as presented in table 1. Whilst the information included in the table is not necessarily comprehensive, it broadly captures the majority of those factors that are associated in the literature with spillovers.[3] The first category of spillovers is defined as intra-industry, which may occur through demonstration effects, competition effects or the labour market. The second classification of spillovers we consider occurs at the inter-industry level, through backward and forward (i.e. intermediate buyer-seller) linkages. Finally, we consider agglomeration spillovers that occur as a result of geographic proximity to foreign firms. Agglomeration spillovers are most likely to be felt through the labour market and local infrastructure arrangements.

Spillovers are traditionally expected to accrue to the industry that the multinational enters, whereby local firms are motivated by competition to improve their productivity (intra-industry spillovers). This may also be due to the belief that firms with similar outputs and activities are most likely to gain access to the MNC's (firm-specific) technology and make use of it through the channels of imitation and labour mobility. The *a priori* assumption in general seems to be that spillovers generate positive effects over and above the direct effects of employment and capital investment. However, there are sensible explanations for situations where intra-industry spillovers may not exist and/or may not be positive. Kugler (2001) discusses the fact that it is unlikely to be in the interests of the MNC voluntarily to share its firm-specific advantages with the domestic sector and it is therefore more likely to make entry decisions on the basis of limiting such spillovers as far as possible. Further, it has been argued that the potential impact of foreign presence may have a negative effect on firms within the same industry; firms may have problems absorbing the latest techniques; they may be pushed further up their average cost curve by the effect of competition from 'better' MNCs which reduces their market share (Aitken and Harrison, 1999); or they may encounter skills mismatches when hiring staff trained by multinationals.

The potential for inter-industry linkages has more recently been considered as a channel through which spillovers might impact on the domestic economy. Kugler (2001) suggests that there is much greater potential for spillovers through forward and backward linkage effects (i.e. in supplier and customer relations) than within the (highly competitive) industry in which the MNC operates. This he attributes to a desire within the MNC to improve the quality of its inputs and court its customers; thus foreign-owned companies will

Table 1. Typology of spillovers

Transmission mechanism	Effect	Likely impact
Intra-industry		
Demonstration effects	Imitation of FDI products and processes; licensing of new technology.	+ive
(c.f. Girma and Wakelin, 2001)	Difficulties in absorption of new technology due to lack of technological complementarities.	-ive
Competition effects	Reduction in costs/inefficiency in order to respond to entry (threat).	+ive
(c.f.Aitken and Harrison 1999)	FDI market share pushes domestic firms up their average cost curves.	-ive
Labour Market	Hiring of FDI-trained staff with improved human capital.	+ive
(c.f.Driffield and Taylor, 2001)	Domestic firms mismatch between current capabilities and human capital of FDI-trained staff.	-ive
Inter-industry		
Forward linkages	Technology transfer and/or new management practices (HRM/JIT) to upgrade quality/lower cost of products demanded by upstream FDI.	+ive
(c.f. Markusen and Venables, 1999; Kugler, 2001)	Difficulties in absorption of new technology/practices; less efficient domestic firms are 'crowded-out'.	-ive
Backward linkages *(c.f.Markusen and Venables, 1999; Kugler, 2001)*	Purchase of improved intermediate products; technological upgrading of own products.	+ive
	Difficulties in absorption of new technology/products; rising costs of domestic suppliers (due to FDI competition) are passed on.	-ive
Agglomeration		
Labour Market *(c.f. Driffield,1999)*	Pool of FDI-trained workers available to local labour markets; increase in entrepreneurial activity (new firm formations).	+ive
	'Poaching' of better staff to FDI (higher pay and career development offered); upward pressure on wage costs.	-ive
Infrastructure *(c.f.Audretsch and Feldman, 1996; Taylor and Wren, 1997)*	Access to greater range of business services (especially R&D which is attracted to service FDI); intra/inter-industry effects stronger in cluster (diminish over space); minimisation of transport costs.	+ive
	Higher costs (e.g. premises); congestion; 'crowding out' due to FDI competition for local resources.	-ive

facilitate technology transfer to their suppliers or buyers (or insist that they adopt new techniques like Just-in-Time inventory processes). He argues that these inter-industry spillovers are also more likely to be generic rather than industry specific. There are however reasons why such spillovers, even with the facilitation of the foreign firms, may not be successful; for example, the problems of firms being able to integrate new technology within their existing practices.

Spillovers from close proximity to foreign firms may be regarded as over-arching the first two sources (inter- and intra-industry spillovers), which by their nature will also have some regional dimension. However, there may be spillovers that neither accrue to the same industrial sector, nor are solely transmitted up or down the supply chain, but are made available purely because of spatial proximity to foreign firms.[4] Audretsch and Feldman (1996) also argue that spillovers are location specific and are likely to decline the further away the domestic firm is from the MNC. Girma and Wakelin (2001) highlight the fact that labour mobility (certainly in the UK) is generally low, thus restricting the diffusion process – through the churning of labour – to the local region. They also point out that the demonstration effect whereby local firms may be able to imitate MNC production is very regional in nature. Finally, they state that forward and backward linkages are likely to be local to minimise transportation costs. Therefore any spillovers to these sectors are likely to diminish quickly over space.

Aside from technological spillovers, the labour market is a key medium through which (particularly intra-industry and agglomeration) spillovers are transmitted. The importance of labour turnover and technology driven training (not only in the production process but also at the management level) is central to the concept of knowledge-based spillovers. Over time, as a result of FDI, domestic firms will acquire information on the latest technology, employ trained staff who can imitate, implement and operate it, and adopt organisational techniques that improve their performance (e.g. the introduction of TQM primarily from Japanese firms).

Market structure is also recognised in recent literature as being an important influence on the level of spillovers, not only in terms of the market the foreign affiliate is entering and operating in, but also in terms of upstream and downstream markets (Markusen and Venables, 1999; Matouschek 2000). Matouschek (*op. cit.*) argues that spillovers will manifest themselves as local downstream firms improve the quality of their inputs to foreign and domestic owned firms alike. These spillovers will only emerge if the MNC chooses an appropriate supplier arrangement to encourage competition in the downstream sector. Kokko (1994) argues that spillovers are less likely to occur in highly differentiated product markets. However, this is complicated by the causal uncertainty that exists in relation to market concentration and multinational presence. Blomstrom and Kokko (1998) argue that it appears as though MNCs are drawn to concentrated industries but do not cause them; however their chief criticism is that much of the literature focuses on entry rather than (longer-term) presence. Therefore, the nature and the level of spillovers is likely to be highly industry specific.

As alluded to above, the ability of firms to internalise spillovers is dependent on their own absorptive capacity. Blomstrom, Globerman and Kokko (2000) consider the costs of foreign owned firms 'supplying' technology being inversely proportional to the level of spillovers to be expected. They suggest that the cost of adoption by the host country firms is also inversely proportional to the level of spillovers. So, when technology is costly to protect, then foreign owned firms are more likely to make it available and when it is costly to acquire, host firms are less likely to seek it. This links clearly to the more recent literature on the 'absorptive capacity' of domestic firms. Blomstrom, Globerman and Kokko (*op. cit.*), Kugler (2001) and Kinoshita (2001), amongst others, acknowledge the importance of the characteristics of the domestic firm, such that the greater the 'technology gap', the less is the likelihood that domestic firms have the ability to adopt the new technologies and techniques (or at least adopt them successfully).[5] Studies on developed countries generally find a positive relationship between foreign presence and productivity but the results for less developed countries is more mixed. Blomstrom, Globerman and Kokko (2000) highlight a problem with the absorption of technology – a *capabilities gap* between the foreign and the indigenous firms. Thus spillovers should be more easily captured when there is a high degree of complementarity between the host and the foreign firm.

Much of the literature focuses on the dispersion of benefits *after* the MNC has located. Kugler (2001) points out that in making an international location decision, *ceteris paribus*, multinational companies are likely to choose to locate where dissipation of monopoly rents from its firm-specific asset are at a minimum – that is, set-up in locations where there is little chance of imitation, and at the same time pay efficiency wage rates such that the rate at which technology leaks is slow enough to ensure that the sunk costs of entry are covered.

In conclusion, a criticism that may be levelled at the literature on spillovers is that it falls short of offering a robust theoretical framework for empirical research. We can say that spillovers may be knowledge or technology based. They may occur through the labour market via skill enhancement, at the regional level and/ or within the same industry or beyond through backward and forward linkages. They probably increase over time, probably vary, depending on which nation is the home for the MNC and their magnitude is likely to depend on the 'absorptive capacity' of domestic plants and so vary across regions and industries. In addition, there is no indication that one sort of spillover will be any more important than another. Ultimately, in measuring spillovers, we are trying to measure the diffusion process which operates through foreign direct investment. Despite the problems of pinpointing exactly what is meant when we aim to measure spillovers, there is general agreement that they will result in higher total factor productivity for domestically-owned plants. We now go on to consider some of the recent empirical findings of spillovers from foreign direct investment in the UK.

3. Recent UK empirical evidence on spillovers

Spillovers have attracted much attention in the academic literature on FDI because of their relevance for industrial policy (Taylor and Wren, 1997; Girma and Wakelin, 2001), particularly within a regional context where, for example, Taylor and Wren estimated that over 40 per cent of regional selective assistance (RSA) funding was invested in foreign-owned plants.

As discussed in the last section, the source of spillovers is hard to define and likely to be multiple. However, there is general agreement that spillovers will manifest through higher levels of productivity. Overall, there are broadly three methodological approaches to spillover measurement. Firstly, there is the case study approach. This allows for comprehensive coverage with relatively accurate firm specific estimates of the importance of MNCs to changes in productivity in local firms. An obvious drawback to this approach is that it tends to be limited to the firms covered by the study and therefore such spillovers will not necessarily translate to other situations; thus a very situation-specific lesson is learnt. Secondly, research has focussed on changes to aggregate productivity, as a result of spillovers from inward investment, using aggregate data (e.g. Driffield, 2000). Indeed, much of the empirical work on spillovers has taken this aggregate (e.g. industry or sectoral) approach. This is primarily because of data limitations although, with the availability of micro datasets such as the Longitudinal Research Database in the US and the Annual Respondents Database in the UK, more recent studies have increasingly sought to identify spillover impacts at the level of the firm or plant. Hence, a third method, and that adopted in this paper, involves estimating plant-level total factor productivity over time. In this section we will concentrate on providing evidence using the last two approaches as being the most relevant here. It is worth noting at the outset that the standard approach (used in all the studies we consider below) is to calculate measures of the extent to which an industry (or region) is dominated by FDI (e.g. the percentage of employment or capital stock accounted for by foreign-owned plants), and then to look for correlations between these indices and (domestic) productivity levels and/or growth. [6]

Using aggregate (sector level) data Barrell and Pain (1997) estimated that FDI accounted for 30 per cent of the increase in productivity between 1985 and 1995.[7] Similarly, Driffield and Taylor (2001) in their study of skills composition (using aggregate data) also note evidence of positive spillovers from FDI. Driffield (2000) also used an aggregated approach to estimate the impact of FDI at the inter- and intra-regional level, as well as the inter- and intra-industry effect for UK manufacturing 1984–92. Using several different measures of foreign investment, he found that there are productivity spillovers from FDI but very small ones, which only occur at the local level. In addition, his results indicate that there are negative spillovers at the industry level.

In contrast, Girma and Wakelin (2001) used plant level data from the ARD to measure agglomeration spillovers in the UK electronics industry. They found that spillovers from Japanese MNCs in particular represent a significant short-run positive impact on productivity (a 10 per cent increase in Japanese FDI leads to a 2.5 per cent increase in domestic productivity) but that these effects are lower for plants located in assisted areas.[8] Girma, Greenaway and Wakelin (2001), using data for UK plants for 1991–6, found labour productivity to be 10 per cent higher and TFP to be around 5 per cent higher in foreign-owned plants, but when they tested for intra-industry spillovers they found none, concluding that financial support for foreign-owned firms on the basis of spillovers may be misguided.

Similar work has been undertaken by Haskel, Pereira and Slaughter (2001), using the ARD to measure the impact of FDI on domestic plant productivity for the purposes of determining whether government financial support (through, for example, regional selective assistance) is generally justified. They consider the impact of foreign ownership in the UK using a pooled approach[9] that allows for intra-industry and regional spillovers. Whilst they do find spillovers to be positive and significant (a 10 per cent increase in foreign ownership leads to 0.5 per cent increase in domestic plants' TFP), they demonstrate that the benefits from FDI may not always outweigh the substantial costs (borne by the government in terms of the assistance offered).

It should be noted that results from previous studies are far from categorical in their support of identifiable spillovers, either in terms of source or presence. In this paper, we also use the ARD for UK manufacturing but, in contrast to previous work, we carry out our analysis at the 4-digit industry level and explicitly allow for the possibility that intra-, inter- and agglomeration spillovers accrue to UK-owned plants during the 1974–95 period. We employ this method for a number of industries in which foreign presence is significantly large enough to allow econometric analysis of this kind in order to consider variations in the spillover impact of foreign ownership across industries. Thus, we extend earlier work carried out by others, by conducting a more detailed analysis and allowing for the various types of spillover effects that have commonly featured in the literature. By so doing, we are also providing consistent empirical results for a number of industries in UK manufacturing, across a common time frame, that also offers an evaluation of the methodology widely used.

4. Data and estimated model

As stated, this study is based on data obtained from the Annual Respondents' Database (ARD). Oulton (1997) and Griffith (1999) provide overviews of the ARD database (but see also Harris, 2002). Each year information is only collected from some 14–19,000 establishments (or reporting units), based on a stratified sampling frame that is heavily biased towards the largest establishments (see Oulton, *op. cit.*, table 1 for details). Thus it is important to calculate sample weights for each establishment (or plant) to ensure that they adequately reflect the underlying distribution in the population.[10]

Data on gross output and intermediate inputs (gross output less gross valued-added) were deflated using 1990 based 4-digit information on producer prices for outputs and inputs.[11] Plant and machinery estimates of the capital stock for each plant are taken from Harris and Drinkwater (2000). These make use of plant-level estimates of capital expenditure based on acquisitions less disposals and including pre-production expenditure (and real expenditure on hire of plant and machinery).

Other data were also available from the ARD. Each plant has a foreign-ownership marker (identifying the country of ownership based on the equity share of the controlling enterprise) and we have grossed-up our estimates of the capital stock to obtain the percentage of industry plant and machinery stock located in foreign-owned plants in each year (for each 4-digit SIC industry). We also calculated similar estimates for each local authority area (using foreign-owned plant and machinery capital stock across all industries in each area and each year) to proxy for agglomeration economies associated with the presence of foreign-owned plants.

To test for spillover effects between foreign- and domestically-owned plants in twenty UK manufacturing industries,[12] we estimated the following augmented log-linear Cobb-Douglas production function for each industry:

$$\begin{aligned}\ln y_{ijt}^{d} &= \alpha \ln x_{ijt}^{d} + \beta \ln l_{ijt}^{d} + \gamma \ln k_{ijt}^{d} \\ &+ \delta t + \theta_1 \sum_{i\in j}(k_{it}^{f} / \sum_{i\in j} k_{it}) \\ &+ \theta_2 \sum_{i\in r}(k_{it}^{f} / \sum_{i\in r} k_{it}) \\ &+ \sum_{m=1,\ldots n} \theta_m \sum_{i\in m, m\neq j}(k_{imt}^{f} / \sum_{i\in m, m\neq j} k_{imt}) \\ &+ a_{it}\end{aligned} \tag{1}$$

where i and t represent the i-th unit and the t-th year of observation, respectively, in industry j or m or local authority r; d and f denote domestic- and foreign-owned plants, respectively; y is real gross output; x is real intermediate inputs (i.e., gross output less gross value added); l is the number of employees (no data on hours are available); k is plant and machinery capital stock; and t is a time-index that starts in 1974. The variable associated with θ_1 measures the proportion of the industry's capital stock operated by foreign-owned plants,[13] and therefore is a proxy for intra-industry effects. In contrast, θ_2 is associated with the proportion of the capital stock operated by foreign-owned plants in local authority area r,[14] and covers all manufacturing industries to try to capture any spatial agglomeration economies. Finally, inter-industry spillovers are represented by the proportion of the capital stock under foreign control in up to n industries, where the latter are linked to industry j as identified in the 1990 UK Industry Input-Output tables.[15]

It is assumed that y, x, l, and k are all potentially endogenous; the intra- and inter-industry measures may be as well but are assumed exogenous in this study to allow estimation without having to use a structural model involving more than one equation.[16] The parameters to be estimated comprise the output elasticities $\alpha,\beta,\gamma,\delta$, while the θ are associated with spillover variables that were initially included and then removed if not significant in a general-to-specific approach to estimation. The error term comprises three elements:

$$a_{it} = \eta_i + t_t + e_{it} \tag{2}$$

with η_i affecting all observations for cross-section unit i; t_t affects all units for time period t; and e_{it} affects only unit i during period t. If e_{it} is serially correlated such that:

$$e_{it} = \rho e_{it-1} + u_{it} \tag{3}$$

where u_{it} is uncorrelated with any other part of the model, and $|\rho| < 1$, then equation (1) can be transformed into a dynamic form involving first-order lags of the variables and a well-behaved error term (see Griffith, *op. cit.*, equations 6–8).

Equation (1), or its dynamic counterpart, can be estimated using the General Method of Moments (GMM) systems approach available in DPD98 (Arellano and Bond, 1998), since this is sufficiently flexible to allow for both endogenous regressors (through the use of appropriate instruments) and a first-order autoregressive error term.[17] All data need also to be weighted to ensure that the samples are representative of the population of UK manufacturing plants under consideration.[18] The main reason for weighting is the problem of endogenous sampling (see the appendix in Harris, 2002), since stratification is based upon employment size and this means that it is likely that the probability of being in the sample is correlated with the variables in the model (particularly ownership attributes and thus productivity) and thus correlated with the model's error term (i.e., $E(z|e) \neq 0$, where z is the vector of regressors in the model).[19]

5. Results and interpretations

The full set of results from estimating equation (1) for each industry are presented in table A1 in the appendix. In terms of diagnostics, all the models estimated were satisfactory in terms of autocorrelation (*cf*. the m1 and m2 test statistics) and the appropriateness of the instrument set used (*cf*. the Sargan test results). The Hausman test that the sampling procedure is exogenous (and thus weighting is unnecessary) confirms that this null hypothesis is satisfactorily rejected in all industries except engineers' small tools. We also report tests of the null that real gross output, intermediate inputs, capital and labour do not form a cointegration vector (using the panel- and group-ADF tests reported in Pedroni, 1999). In all cases, this null is rejected and therefore we are confident that we are able to avoid the problem of spurious regressions.

Our main concern here is whether there is evidence of spillovers; a summary of the results (based on table A1) is reported in table 2. In over one third of the industries we cover, there is no statistically significant evidence of an intra-industry effect on domestic plants. For those industries where there was an impact, some are positively affected by foreign-owned plants (concrete and cement, organic chemicals, electronic data processing, electronic sub-assemblies, aerospace, and the preparation of milk products), and in others the competition effect of foreign ownership was presumably stronger, leading to an overall negative impact (pharmaceuticals, engineers' small tools, mechanical equipment, various food products, and certain paper and publishing industries).

As to agglomeration effects (mainly associated with such factors as local labour market external economies

Table 2. Summary of weighted system estimates of spillover effects (based on Cobb-Douglas production function, 1974–95: UK manufacturing, various industries)

Type of spillover	Steel wire (SIC2234)	Concrete, cement, plaster (SIC2437)	Ceramic goods (SIC2489)	Organic chemicals (SIC2512)	Pharma-ceutical products (SIC2570)	Engineers' small tools (SIC3222)	Mechanical equipment (SIC3255)	Refrigerating machinery (SIC3284)	Electronic data processing (SIC3302)	Other electronic equipment (SIC3444)
Intra-industry	n.s.	+	n.s.	+	–	–	–	n.s.	+	n.s.
Agglomeration	n.s.	–	n.s.	–	+	n.s.	+	n.s.	n.s.	n.s.
Forward (+ive)	3	3	2	7		2	4	2		1
Forward (–ive)	5	2	1	2		3	1	3		
Backward (+ive)	2		2	2	4	10	8	2	1	
Backward (–ive)	1	1	3	4	1	10	2	3	1	2

Type of spillover	Electronic sub-assemblies (SIC3453)	Motor vehicles & their engines (SIC3510)	Aero-space equip-ment (SIC3640)	Preparation of milk products (SIC4130)	Cocoa, etc confect-ionery (SIC4214)	Miscel-laneous foods (SIC4239)	Packaging of paper and pulp (SIC4724)	Print/publishing of period-icals (SIC4752)	Plastics semi-manu-factures (SIC4832)	Other manu-factures n.e.s. (SIC4959)
Intra-industry	+	n.s.	+	+	–	–	–	–	n.s.	n.s.
Agglomeration	n.s.	n.s.	n.s.	+	–	n.s.	n.s.	–	n.s.	n.s.
Forward (+ive)	2			3	1	2	1	3	3	1
Forward (–ive)	2			4		5	1	2	3	3
Backward (+ive)	2	2	2	2	2	4	3	3	5	3
Backward (–ive)	4	1	2	4	2	2	1	2	2	4

Notes: See table A1 for full details. + = positive effect; – = negative effect. All parameter estimates are significant at the 5 per cent level (or better) n.s. not significant at 5 per cent level. Individual numbers represent the number of industries with significant parameter estimates.

of scale), we found no evidence of any spatial spillovers on two thirds of the industries covered. In the seven industries with significant effects, three experienced external economies while in four industries a larger local presence of foreign-owned plants resulted in external diseconomies prevailing. In particular, we find no evidence of agglomeration economies in the high-tech electronics industries (which suggests either that such effects are not present or that they are confined to a smaller number of local labour market areas than are covered here).[20]

Inter-industry spillovers would seem to be particularly important in some industries (e.g. engineers' small tools), and this may reflect both the extent to which such industries have strong forward and backward linkages and the presence of FDI in interrelated industries. However, we can find no clear pattern in terms of which industries experienced spillovers, the extent of these (in terms of the number of industries linked), and the balance between positive and negative spillovers. Indeed, in a number of instances there is a positive link between a forward- or backward-linked industry and one of the twenty industries studied here, while in another estimate of equation (1) the impact of the same interrelated industry is negative (cf. the impact of SIC2210 – iron & steel – is positive on mechanical lifting and handling equipment and negative for refrigerating machinery, as table A1 shows). What we can conclude, however, is that the evidence presented here (table 2) shows that inter-industry spillovers are just as likely to be negative as positive; there is no clear evidence of an overall beneficial effect on UK manufacturing that results from (supply-side) linkages associated with FDI.

The overall magnitude of the various spillover effects on the level of productivity is of interest, and therefore table 3 contains the percentage contribution that spillovers have made in each of the twenty industries (which takes into account the relative sizes of the industries and regions). These numbers are based on the predicted values obtained from the estimated equations, reported in the appendix table A1. It can be seen that agglomeration spillovers are particularly small and are frequently negative in impact, highlighting the results in table 2 which indicated the relatively small contribution such spillovers make. In contrast, the intra-industry impact in the case of some industries is large, though not always positive, particularly in the case of engineers' small tools and miscellaneous foods. In the case of the latter, inter-industry spillovers compounded the overall effect, whereas in the case of engineers' small tools, inter-industry spillovers offset the negative impact of intra-industry competition. This may be related to the fact that miscellaneous foods may well be closer to the end stage of the production processes in general, whereas engineers' small tools are likely to produce inputs into other production processes.

Table 3 also reports the total impact for the net contribution of all the twenty industries included in this analysis; however, it should be stressed that this is a sample of FDI interests in UK manufacturing and is therefore indicative of the net impact for these industries only, and **not** for UK manufacturing as a whole. However, in terms of the industries chosen, the overall spillover impact has been positive, accounting for 13 per cent of the overall output from these twenty industries. The breakdown between types of spillovers indicates that this has been largely the result of inter-

Table 3. Net percentage contribution of spillover effects[(a)] to output (1974–95)

SIC	Industry	% contribution of spillovers to gross output	% contribution from intra-industry spillovers	% contribution from agglomeration spillovers
2234	Steel wire	31.1	0.0	0.0
2437	Concrete, cement, plaster	48.7	12.3	–2.7
2489	Ceramic goods	–48.9	0.0	0.0
2512	Organic chemicals	65.0	7.0	–0.7
2570	Pharmaceutical products	–4.2	–3.7	–1.1
3222	Engineers' small tools	–37.1	–54.5	0.0
3255	Mechanical equipment	62.0	–33.3	1.8
3284	Refrigerating machinery	36.4	0.0	0.0
3302	Electronic data processing	49.4	35.8	0.0
3444	Other electronic equipment	0.5	0.0	0.0
3453	Electronic sub-assemblies	–36.7	83.3	0.0
3510	Motor vehicles & their engines	–0.5	0.0	0.0
3640	Aerospace equipment	26.6	5.6	0.0
4130	Preparation of milk products	49.8	9.9	0.0
4214	Cocoa, etc. confectionery	33.6	–2.5	–1.0
4239	Miscellaneous foods	–60.7	–57.3	0.0
4724	Packaging of paper and pulp	34.4	–5.0	0.0
4752	Print/publishing of periodicals	99.7	–3.8	–2.3
4832	Plastics semi-manufactures	–125.1	0.0	0.0
4959	Other manufactures n.e.s.	295.0	0.0	0.0
Total		13.0	–5.5	–0.3

Note: (a) Based on long run coefficient estimates.

and not the commonly looked for intra-industry spillovers, offering considerable support for the arguments put forward by Kugler (2001), discussed above.

6. Conclusions and policy implications

It is generally accepted in the literature that spillovers from FDI occur and are beneficial to the host economy. For instance, Blomstrom, Globerman and Kokko (2000, p. 28) summarise an extension empirical literature and conclude: "... the evidence is convincing in showing the existence of FDI efficiency spillovers in host countries, although there is no strong consensus on the associated magnitudes". Other studies using aggregated and disaggregated UK data have also found positive impacts associated with intra-industry, inter-industry and spatial agglomeration effects, as proxied by the relative importance of FDI in associated industries and regions.

This study uses UK-owned plant-level data for twenty UK manufacturing industries (covering 1974–95) and includes measures for intra-industry, inter-industry and agglomeration linkages at the local authority level of analysis. Our proxies for these effects are comparable to those employed by others – i.e. based on FDI shares (of capital stock in our case). Our results show no clear pattern in terms of which industries experienced spillovers, the extent of these (in terms of the number of industries linked), and the balance between positive and negative spillovers. Indeed, inter-industry spillovers are just as likely to be negative as positive and so there is no clear evidence of an overall beneficial effect on UK manufacturing resulting from (supply-side) linkages associated with FDI.

Thus, from this study we can conclude that FDI spillovers, where they occur, are not automatically positive, and thus from a policy perspective, the assumption that FDI is beneficial to the host region is open to question. However, it is also apparent that the standard methodology for measuring spillover effects is also open to criticism. Most importantly, we do not actually observe linkages between FDI plants and domestic plants and thus the methodology currently applied here, and in many other studies, may be regarded as inadequate (or at least involves the use of poor proxies) for explaining the indirect effects of foreign firms on domestic firms. It is possible that in some cases FDI plants buy and sell mostly (or even exclusively) from other parts of the MNC (wherever these plants may be located). In short, what is lacking is direct evidence of the size and scope of FDI linkages, and therefore correlations between the magnitude of FDI presence in various industries (or locations) and plant-level TFP in domestic firms is at best an inexact indicator of the importance of FDI spillover effects. What does seem evident from this and other studies is that better data and/or case study work are clearly needed to explain properly the link between foreign presence and domestic productivity changes.

Appendix

The ARD Database: sample weights and price indices

The 'weights' were calculated at the 4-digit industry level broken down into five size-bands and the status of the plant (in terms of whether it opened that year, closed the next year, or neither of these two categories). When there were less than five observations in each sub-group (industry × size-band × open/close status) then size-bands were amalgamated. If there were still insufficient observations, then status was dropped, and finally (if necessary) the industry definition moved from a 4-digit to a 3-digit classification. Note, the 1980 Standard Industrial Classification was used throughout, with plants from 1970–79 reclassified from the 1968 SIC while 1994 data necessitated recoding from the 1992 SIC.

As to price indices, the 1974–9 gross output and intermediate inputs data was deflated using PPI indices (output and inputs) based on the 1968 SIC. The 1994 data uses 1992 SIC price indices. All price indices are published in the Annual Abstract of Statistics (various years) and a series from 1978–93 was obtained directly from the ONS at Newport, South Wales.

The ARD Database: plants versus establishments

Information is held on every plant with respect to its employment and certain characteristics (such as location; ownership; industry classification, etc.). However, each year financial information is collected from only some 14–19 thousand establishments, based on a sampling frame that is heavily biased towards the largest establishments (see Oulton, 1997, table 2 for details).

There is an issue as to whether plant level data should be preferred to establishment data when carrying out analyses using the ARD. However, the establishment is not an economic unit, like a plant; it is an accounting unit that often gains and loses plants because of changes in the way enterprises choose to collect financial data and respond to the Government's requests for information. The composition of an establishment (in terms of the number of plants covered) can change as companies open and close plants, or buy and sell plants. A typical establishment includes plants of different sizes and different vintages, and with relatively frequent compositional changes over time this makes it difficult to undertake certain types of analysis in a economically meaningful way (e.g., analyses of opening and closures, and calculating relevant measures of capital stock using historical data on past fixed investment). Harris and Drinkwater (2000) further discuss this issue and provide evidence on how unstable establishments are over time (in terms of compositional changes).[21] Thus, it is argued that plant level data is clearly more appropriate when undertaking work with the ARD.

NOTES

1 It is not our intention here to review the direct benefits that arise from FDI; for a more detailed discussion on this issue see Harris and Robinson (2003).
2 Arguably, there could be a crowding out effect, displacing domestic firms, which would not be desirable from the hosts' perspective. In addition, the expatriation of profits might result in a fall in national income, despite a rise in national output.
3 See Blomstrom, Globerman and Kokko (2000) for a broader framework.
4 Cantwell (1991) states that agglomeration economies are likely to be strong in high technology industries.
5 Others have argued, the greater the gap, the greater the positive spillover could be (cf. Kathuria, 2001; although Kathuria qualifies this argument by stating that firms need to possess R&D capabilities).
6 That is, the standard form of measurement in both the second and third methods discussed here is through a 'proportion of foreign ownership variable' in the production function (or similar). This varies according to what type of spillovers are expected; for example, Aitken and Harrison (1999) look for intra-industry spillovers and thus use the proportion of employment in foreign owned firms within the industry as an explanatory variable. When they consider the potential for agglomeration spillovers, they use the proportion of employment in foreign owned firms within the region as an explanatory variable (equation (1), pp. 607 and 612).
7 Later work by Hubert and Pain (2001), using a similar approach, confirms that FDI has a large positive impact.
8 They suggest that this indicates that locational impacts are significant in the UK and that causing MNCs to locate in assisted areas is not always the way to derive the maximum spillover benefit.
9 That is, they do not estimate production function-based models at the industry or sub-regional level, but include dummies to control for such effects.
10 The appendix to Harris (2002) provides an extensive discussion of the importance of weighting data in the type of empirical work considered here.
11 The appendix provides details on the deflators used.
12 Harris and Robinson (2003) present background information on how (and why) these industries were chosen, as well as data for each industry.
13 We experimented with employment shares, but found no substantial differences in our results.
14 We prefer to disaggregate down to this spatial unit as it is much closer to the notion of a local labour market than is a standard UK region (e.g., the SE of England).
15 We identified the relevant 4-digit industries to include (via either forward- or backward linkages) using a cut-off point that the industry must demand/supply at least 5 per cent of gross output in industry *j*.
16 In particular, the intra-industry measures are likely to involve some form of endogenous feedback (especially when FDI is small and growing rapidly). While in general we have assumed these spillover terms are endogenous, we have undertaken some limited experimentation with lagged instruments for these variables. Generally, we either found little change in our final results (or the DPD model became unstable producing implausible results).
17 Using the GMM systems approach the model is estimated in both levels and first-differences. This is important, since Blundell and Bond (1999) argue that including both lagged levels and lagged first-differenced instruments leads to significant reductions in finite sample bias as a result of exploiting the additional moment conditions inherent from taking their system approach.
18 Note the data had to be weighted prior to use in the DPD module available in PcGive 10 (and thus any automatically generated constant terms were suppressed).
19 Since the unweighted estimator is consistent when the sampling is exogenous, and the weighted estimator is consistent with or without exogenous sampling, a Hausman (1978) test will be used to test for exogeneity of the sampling procedure.
20 A third possible explanation of course – which we discuss in our conclusions – is that the approach used (in terms of how we proxy for potential spillover effects) is flawed.
21 As an example, an examination of the ARD shows that 20 per cent of reporting establishments in Motor Vehicles and Their Engines (SIC3510), that existed throughout the period 1974–93, experienced changes with regard to which plants they contained (see Harris, 2002).

Table A1. Weighted system estimates of plant-level dynamic Cobb-Douglas production function, 1974–95: various UK manufacturing industries (UK-owned plants only)

Dependent variable: *ln* real gross output y_t	Steel Wire (2234)		Other building products of concrete, cement, plaster (2437)		Ceramic goods (2489)	
	$\hat{\beta}$	*t*-value	$\hat{\beta}$	*t*-value	$\hat{\beta}$	*t*-value
ln real gross output (y_{it-1})	0.135	3.04	0.225	7.88	0.334	5.40
ln real intermediate input (x_{it})	0.809	44.40	0.682	33.40	0.754	13.90
ln real intermediate input (x_{it-1})	–0.110	–2.83	–0.154	–6.41	–0.257	–4.94
ln employment (l_{it})	0.172	8.54	0.313	15.40	0.268	6.05
ln employment (l_{it-1})	–0.016	–2.35	–0.045	–6.28	–0.088	–5.37
ln P&M capital stock (k_{it})	0.120	2.28	0.119	2.77	0.163	2.47
ln P&M capital stock (k_{it-1})			–0.018	–3.22	–0.014	–2.35
t			0.014	7.90	0.004	1.24
Constant	–0.244	–3.19	–0.928	–10.30	–0.110	–0.466
Spillover impacts						
Intra–industry			0.010	2.87		
Agglomeration			–0.001	–2.70		
Inter–industry						
SIC2220					–0.029	–6.83
SIC2235	0.021	7.88			0.011	2.72
SIC2247	0.005	4.71				
SIC2310					0.021	2.93
SIC2420			–0.088	–11.20		
SIC2551					–0.004	–2.03
SIC3111			–0.002	–2.30		
SIC3112			–0.007	–4.94		
SIC3137	0.005	2.89				
SIC3138			0.013	4.83		
SIC3161	–0.003	–3.34				
SIC3162	–0.002	–4.78				
SIC3163	–0.002	–5.16				
SIC3284	–0.006	–5.51				
SIC3288	0.004	6.80				
SIC3510			0.004	6.75		
SIC3522					0.002	2.35
SIC3523	–0.007	–3.67				
SIC3530			0.002	3.30		
SIC4728					–0.003	–3.35
SIC4751					–0.003	–2.20
SIC4753					0.022	6.56
Sargan test (P-value)	245.200	[0.958]	522.5	[0.486]	188.700	[0.211]
m1 (P-value)	–4.633	[0.000]	–6.603	[0.000]	–4.851	[0.000]
m2 (P-value)	–1.306	[0.192]	–1.154	[0.248]	0.361	[0.718]
Hausman χ^2 test (P-value)	12.097	[0.021]	8.066	[0.092]	28.874	[0.000]
Panel ADF statistic (P-value)	–17.866	[0.000]	–30.073	[0.000]	–18.478	[0.000]
Group ADF statistic (P-value)	–27.954	[0.000]	–76.620	[0.000]	–66.556	[0.000]
Instruments	Δt–1, t–2		Δt–1, t–2		Δt–1, t–2	
No. of units	266		579		236	
No. of observations	2526		5267		2655	

Notes: the samples are unbalanced (weighted) panels estimated in the DPD algorithm in PcGive 10; all *t*-values are based on two-step robust standard errors; m1 and m2 are tests for first and second order serial correlation; the GMM estimator has the instruments (for *x*, *l* and *k*) dated as shown. The Hausman (1978) test is for the exogeneity of the (stratified) sampling procedure. The Panel- and Group-ADF tests are for cointegration of real gross output, real intermediate inputs, employment and the real capital stock based on Pedroni (1999).

Table A1 (continued)

Dependent variable:	Organic chemicals, not pharmaceutical (2512)		Pharmaceutical products (2570)		Engineers' small tools (3222)	
	$\hat{\beta}$	*t*-value	$\hat{\beta}$	*t*-value	$\hat{\beta}$	*t*-value
ln real gross output (y_{it-1})	0.270	9.41	0.515	14.60	0.234	6.29
ln real intermediate input (x_{it})	0.897	51.8	0.677	13.60	0.456	10.7
ln real intermediate input (x_{it-1})	–0.230	–10.2	–0.405	–15.20	–0.125	–5.05
ln employment (l_{it})	0.105	5.95	0.315	6.14	0.509	10.5
ln employment (l_{it-1})	–0.036	–3.24	–0.094	–6.45	–0.035	–2.69
ln P&M capital stock (k_{it})	0.089	2.66	0.143	2.64	0.121	2.41
ln P&M capital stock (k_{it-1})	–0.018	–2.31				
t			0.016	3.97	0.048	3.36
Constant	–1.322	–7.49	–0.316	–1.05	–0.018	–7.13
Spillover impacts						
Intra–industry	0.008	4.29	–0.015	–4.21	–0.038	–5.49
Agglomeration	–0.001	–1.60	0.001	1.64		
Inter–industry						
SIC2234					0.007	1.79
SIC2235					0.038	3.30
SIC2511	0.007	4.74				
SIC2512	0.008	4.29	0.005	3.85		
SIC2513	–0.004	–5.36				
SIC2514	–0.005	–11.2				
SIC2516	0.048	9.25				
SIC2552	0.009	4.85				
SIC2562	0.005	2.95				
SIC2565	0.015	6.25				
SIC2567	0.009	1.93				
SIC2568	0.005	8.52				
SIC2569	–0.012	–7.59				
SIC2570	0.021	7.72				
SIC3111					0.024	4.01
SIC3112					0.018	3.20
SIC3120					0.021	2.17
SIC3137					–0.034	–2.54
SIC3138					–0.074	–7.16
SIC3164	0.004	2.54	0.002	2.91		
SIC3244	–0.040	–5.38				
SIC3245	–0.010	–4.49				
SIC3246	–0.005	–5.58				
SIC3281					–0.010	–1.97
SIC3283					–0.008	–3.07
SIC3284					–0.055	–7.18
SIC3285					0.024	4.88
SIC3286					–0.006	–4.56
SIC3287					–0.004	–1.40
SIC3288					0.015	6.70
SIC3289					0.111	7.81
SIC3510					–0.022	–5.64
SIC3521					0.034	5.86
SIC3522					–0.011	–5.74
SIC3523					–0.033	–4.83
SIC3530					0.016	7.37
SIC4723			–0.011	–3.53		
SIC4725			0.010	3.13		
SIC4836			0.028	5.35		
Sargan test (P–value)	108.1	[1.000]	166.9	[0.999]	165.0	[0.295]
m1 (P–value)	–4.961	[0.000]	–6.654	[0.000]	–8.461	[0.000]
m2 (P–value)	–1.609	[0.108]	1.505	[0.132]	0.171	[0.864]
Hausman χ^2 test (P–value)	2081.639	0.00	19.305	0.00	4.087	0.25
Panel ADF statistic (P–value)	–12.559	0.00	–21.317	0.00	–29.328	0.00
Group ADF statistic (P–value)	–44.458	0.00	–67.661	0.00	–138.157	0.00
Instruments	Δt–1, t–2		Δt–1, t–2		Δt–3, t–4	
No. of units	127		179		461	
No. of observations	1287		1890		3786	

Table A1 (continued)

Dependent variable:	Mechanical lifting and handling equipment (3255)		Refrigerating machinery and air conditioning (3284)		Electronic data processing equipment (3302)	
	$\hat{\beta}$	*t*-value	$\hat{\beta}$	*t*-value	$\hat{\beta}$	*t*-value
ln real gross output (y_{it-1})	0.197	7.07	0.164	5.75	0.514	9.68
ln real intermediate input (x_{it})	0.632	21.1	0.675	27.9	0.646	11.2
ln real intermediate input (x_{it-1})	–0.141	–6.88	–0.114	–4.61	–0.399	–7.81
ln employment (l_{it})	0.326	9.06	0.350	14.30	0.264	4.54
ln employment (l_{it-1})	–0.024	–4.39	–0.052	–8.35	–0.047	–2.99
ln P&M capital stock (k_{it})	0.131	2.94	0.112	2.51	0.134	2.63
ln P&M capital stock (k_{it-1})	–0.025	–11.50				
t	0.032	7.42			0.028	6.48
Constant	–0.887	–5.63	–0.891	–7.84	–1.196	–4.90
Spillover impacts						
Intra–industry	–0.013	–6.68			0.005	3.48
Agglomeration	0.001	1.85				
Inter–industry						
SIC2210	0.044	5.28	–0.011	–4.85		
SIC2234	0.017	10.4				
SIC2235			0.023	4.72		
SIC3111			–0.010	–4.98		
SIC3112	0.016	5.66				
SIC3120	–0.039	–13.8			–0.016	–2.98
SIC3137			0.037	5.56		
SIC3138	0.016	3.68	–0.008	–3.07	0.048	5.05
SIC3204	0.008	6.85				
SIC3205	0.015	8.83				
SIC3251			0.020	8.72		
SIC3255			–0.018	–6.19		
SIC3281	0.014	7.97				
SIC3283	0.009	4.56				
SIC3288	–0.012	–7.90				
SIC3420			–0.006	–5.44		
SIC3610			–0.013	–2.33		
SIC3640			0.048	6.80		
Sargan test (P–value)	313.6	[0.173]	353.600	[0.745]	125.800	[1.000]
m1 (P–value)	–7.482	[0.000]	–4.716	[0.000]	–4.801	[0.000]
m2 (P–value)	2.004	[0.005]	–1.485	[0.137]	–0.426	[0.670]
Hausman χ^2 test (P–value)	50.846	0.00	41.717	0.00	12.520	0.01
Panel ADF statistic (P–value)	–34.178	0.00	–29.522	0.00	–6.398	0.00
Group ADF statistic (P–value)	–93.216	0.00	–84.743	0.00	–62.703	0.00
Instruments	Δt–3, t–4		Δt–1, t–2		Δt–1, t–2	
No. of units	399		392		133	
No. of observations	3268		3310		929	

Table A1 (continued)

Dependent variable:	Other components for electronic equipment (3444)		Active components and electronic sub-assemblies (3453)		Motor vehicles and their engines (3510)	
	$\hat{\beta}$	*t*-value	$\hat{\beta}$	*t*-value	$\hat{\beta}$	*t*-value
ln real gross output (y_{it-1})	0.181	3.63	0.223	5.64		
ln real intermediate input (x_{it})	0.502	9.61	0.549	11.20	0.428	2.70
ln real intermediate input (x_{it-1})	–0.114	–2.47	–0.094	–2.55	0.057	2.47
ln employment (l_{it})	0.458	7.67	0.414	7.45	0.506	3.36
ln employment (l_{it-1})	–0.025	–2.26	–0.072	–3.76		
ln P&M capital stock (k_{it})	0.129	1.90	0.108	3.35	0.193	2.08
ln P&M capital stock (k_{it-1})	–0.013	–4.53	–0.066	–2.19		
t	0.026	6.92	0.086	6.95		
Constant	–1.500	–5.48	–1.063	–2.86	–1.224	–2.27
Spillover impacts						
Intra–industry			0.034	5.53		
Agglomeration						
Inter–industry						
SIC2210					0.055	2.17
SIC2246	–0.001	–5.22				
SIC2247			–0.033	–7.43		
SIC2310						
SIC2565			–0.054	–8.02		
SIC2569			–0.016	–4.63		
SIC3112	–0.010	–4.91	0.031	7.22		
SIC3120			0.069	5.40	–0.022	–2.76
SIC3138			–0.024	–3.08	0.015	1.72
SIC3301			0.016	8.03		
SIC3302			0.003	2.98		
SIC3441	0.003	2.75				
SIC3442			–0.014	–4.55		
SIC3443			–0.125	–6.61		
Sargan test (P–value)	279.5	[0.362]	127.300	[0.987]	70.29	[0.999]
m1 (P–value)	–2.448	[0.014]	–6.024	[0.000]	–3.117	[0.002]
m2 (P–value)	0.367	[0.713]	2.493	[0.013]	–0.540	[0.590]
Hausman χ^2 test (P–value)	48.628	0.00	8.892	0.03	17.100	0.00
Panel ADF statistic (P–value)	–23.785	0.00	–14.341	0.00	–22.453	0.00
Group ADF statistic (P–value)	–75.241	0.00	–57.748	0.00	–59.334	0.00
Instruments	Δt–1, t–2		Δt–2, t–3		Δt–8, t–9	
No. of units	289		142		166	
No. of observations	2621		1193		1501	

Table A1 (continued)

Dependent variable:	Aerospace equipment (3640)		Preparation of milk and milk products (4130)		Cocoa, chocolate and sugar confectionery (4214)	
	$\hat{\beta}$	*t*-value	$\hat{\beta}$	*t*-value	$\hat{\beta}$	*t*-value
ln real gross output (y_{it-1})	0.358	4.73	0.210	3.28	0.265	4.18
ln real intermediate input (x_{it})	0.648	6.25	0.878	80.60	0.663	10.30
ln real intermediate input (x_{it-1})	–0.216	–2.97	–0.172	–3.00	–0.161	–3.08
ln employment (l_{it})	0.313	5.12	0.125	10.30	0.298	5.64
ln employment (l_{it-1})	–0.073	–5.68	–0.031	–3.94	–0.056	–4.41
ln P&M capital stock (k_{it})	0.136	2.30	0.090	2.16	0.158	2.50
ln P&M capital stock (k_{it-1})	–0.060	–2.70			–0.044	–2.44
t	0.017	3.12	0.021	3.97	0.024	7.17
Constant	–1.247	–4.70	–0.593	–4.32	–0.704	–3.19
Spillover impacts						
Intra–industry	0.006	2.41	0.020	5.11	–0.001	–4.94
Agglomeration					–0.001	–1.76
Inter–industry						
SIC3120	–0.009	–2.86				
SIC3164					0.003	3.52
SIC3286	0.002	2.27				
SIC3289	0.017	2.53				
SIC3443	–0.008	–1.69				
SIC4123			–0.009	–6.11		
SIC4126			–0.002	–2.75		
SIC4196			–0.046	–2.93		
SIC4197			–0.008	–8.45	0.005	6.40
SIC4200					–4.388	–5.30
SIC4214			0.007	6.59		
SIC4221			0.011	5.44		
SIC4222			–0.008	–7.19		
SIC4239			0.020	5.89		
SIC4283			–0.011	–7.03		
SIC4723			–0.025	–5.20		
SIC4724			–0.019	–7.77		
SIC4725			0.033	6.44		
SIC4728			–0.004	–3.33		
SIC4834			0.011	5.56		
SIC4835					–0.006	–3.23
SIC4836					0.032	8.32
Sargan test (P-value)	98.57	[1.000]	386.60	[0.092]	166.100	[0.460]
m1 (P-value)	–3.314	[0.001]	–5.085	[0.000]	–4.147	[0.000]
m2 (P-value)	0.772	[0.440]	0.287	[0.774]	–0.843	[0.399]
Hausman χ^2 test (P-value)	17.100	0.00	136.098	0.00	58.278	0.00
Panel ADF statistic (P-value)	–28.199	0.00	–26.130	0.00	–11.356	0.00
Group ADF statistic (P-value)	–72.718	0.00	–74.255	0.00	–41.523	0.00
Instruments	Δt–1, t–2		Δt–2, t–3		Δt–2, t–3	
No. of units	111		465		185	
No. of observations	1043		5132		1813	

Table A1 (continued)

Dependent variable:	Miscellaneous foods (4239)		Packaging products of paper and pulp (4724)		Printing and publishing of periodicals (4752)	
	$\hat{\beta}$	*t*-value	$\hat{\beta}$	*t*-value	$\hat{\beta}$	*t*-value
ln real gross output (y_{it-1})	0.266	6.08			0.374	9.10
ln real gross output (y_{it-2})						
ln real intermediate input (x_{it})	0.784	37.80	0.694	11.5	0.669	23.10
ln real intermediate input (x_{it-1})	–0.188	–5.46			–0.274	–8.47
ln employment (l_{it})	0.245	11.10	0.237	3.71	0.337	10.2
ln employment (l_{it-1})	–0.080	–6.96			–0.088	–8.51
ln P&M capital stock (k_{it})	0.149	1.96	0.103	2.32	0.163	2.36
ln P&M capital stock (k_{it-1})	–0.020	–1.83				
t	0.061	6.30	0.005	1.84	0.026	5.30
Constant	0.443	2.78	–0.631	–2.32	–1.242	–6.24
Spillover impacts						
Intra–industry	–0.021	–9.39	–0.003	–1.71	–0.003	–3.88
Agglomeration					–0.002	–2.95
Inter–industry						
SIC2562					0.002	2.44
SIC2563					–0.004	–2.57
SIC2565					0.005	2.98
SIC2567					–0.005	–3.87
SIC2569					0.011	3.93
SIC3164	0.007	8.44				
SIC3302			–0.003	–3.21		
SIC3510					–0.007	–3.21
SIC3521					0.043	5.79
SIC3523					0.012	2.30
SIC3530					–0.004	–3.67
SIC4121	–0.034	–5.50				
SIC4122	–0.048	–12.50				
SIC4126	–0.002	–3.44	0.002	2.24		
SIC4147	0.010	6.53				
SIC4150	0.030	10.50				
SIC4196	–0.181	–9.19				
SIC4197	–0.038	–12.60				
SIC4239					0.019	6.05
SIC4832	–0.040	–13.20	0.008	2.64		
SIC4833	0.012	11.80				
SIC4834	0.031	13.9	–0.009	–6.60		
SIC4835	–0.023	–12.30	0.007	3.04		
SIC4836	0.038	8.48	0.031	7.33		
Sargan test (P–value)	165.200	[0.481]	132.0	[0.972]	326.300	[0.500]
m1 (P–value)	–5.946	[0.000]	–4.614	[0.000]	–7.252	[0.000]
m2 (P–value)	1.442	[0.149]	–0.924	[0.355]	1.983	[0.047]
Hausman χ^2 test (P–value)	25.010	0.00	146.520	0.00	6134.197	0.00
Panel ADF statistic (P–value)	–41.363	0.00	–13.269	0.00	–26.195	0.00
Group ADF statistic (P–value)	–84.379	0.00	–36.565	0.00	–99.129	0.00
Instruments	Δt–2, t–3		Δt–2, t–3		Δt–1, t–2	
No. of units	302		143		349	
No. of observations	3125		1440		2960	

Table A1 (continued)

Dependent variable:	Plastics semi-manufactures (4832)		Other manufactures not elsewhere specified (4959)	
	$\hat{\beta}$	*t*-value	$\hat{\beta}$	*t*-value
ln real gross output (y_{it-1})	0.386	8.36	0.274	4.32
ln real intermediate input (x_{it})	0.799	35.40	0.715	18.50
ln real intermediate input (x_{it-1})	–0.317	–8.13	–0.208	–3.69
ln employment (l_{it})	0.208	8.55	0.285	5.51
ln employment (l_{it-1})	–0.071	–6.92	–0.041	–1.64
ln P&M capital stock (k_{it})	0.168	2.61	0.102	1.84
ln P&M capital stock (k_{it-1})	–0.013	–1.64		
t	0.065	9.00	0.004	0.68
Constant	–0.753	–5.41	–0.521	–2.17
Spillover impacts				
Intra-industry				
Agglomeration				
Inter-industry				
SIC2514	0.006	8.25		
SIC2515	–0.005	–7.10		
SIC2581	0.010	5.86		
SIC2582	–0.037	–8.95		
SIC3161	–0.023	–8.40	0.007	3.47
SIC3162	0.011	7.84	–0.003	–2.37
SIC3163	0.003	4.06		
SIC3165	0.023	7.61		
SIC3169	0.025	6.82	0.011	2.94
SIC3521	0.018	4.19		
SIC3522	–0.009	–4.67		
SIC3523	0.112	9.14		
SIC3530	–0.008	9.04		
SIC4710			–0.008	–5.00
SIC4721			–0.009	–4.15
SIC4722			0.003	4.98
SIC4724			–0.019	–7.99
SIC4752			–0.003	–2.09
SIC4753			0.046	6.60
SIC4754			–0.024	–3.45
SIC4835			–0.004	–2.17
Sargan test (P-value)	178.400	[0.994]	172.500	[0.328]
m1 (P-value)	–5.053	[0.000]	–5.156	[0.000]
m2 (P-value)	0.889	[0.374]	1.937	[0.053]
Hausman χ^2 test (P-value)	702.129	0.00	22.215	0.00
Panel ADF statistic (P-value)	–25.879	0.00	–16.812	0.00
Group ADF statistic (P-value)	–53.318	0.00	–47.387	0.00
Instruments	Δt–1, t–2		Δt–2, t–3	
No. of units	190		210	
No. of observations	1569		1658	

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